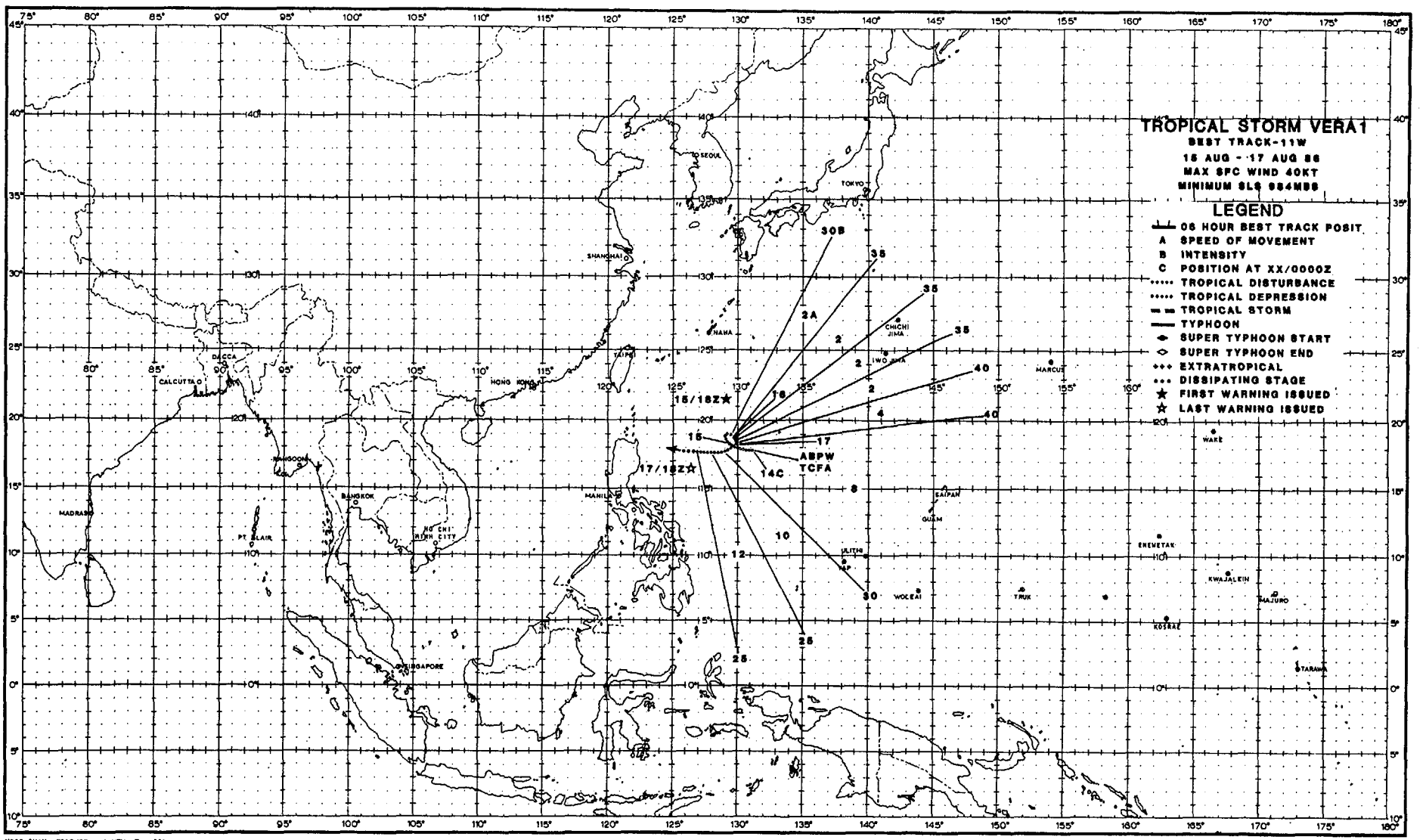
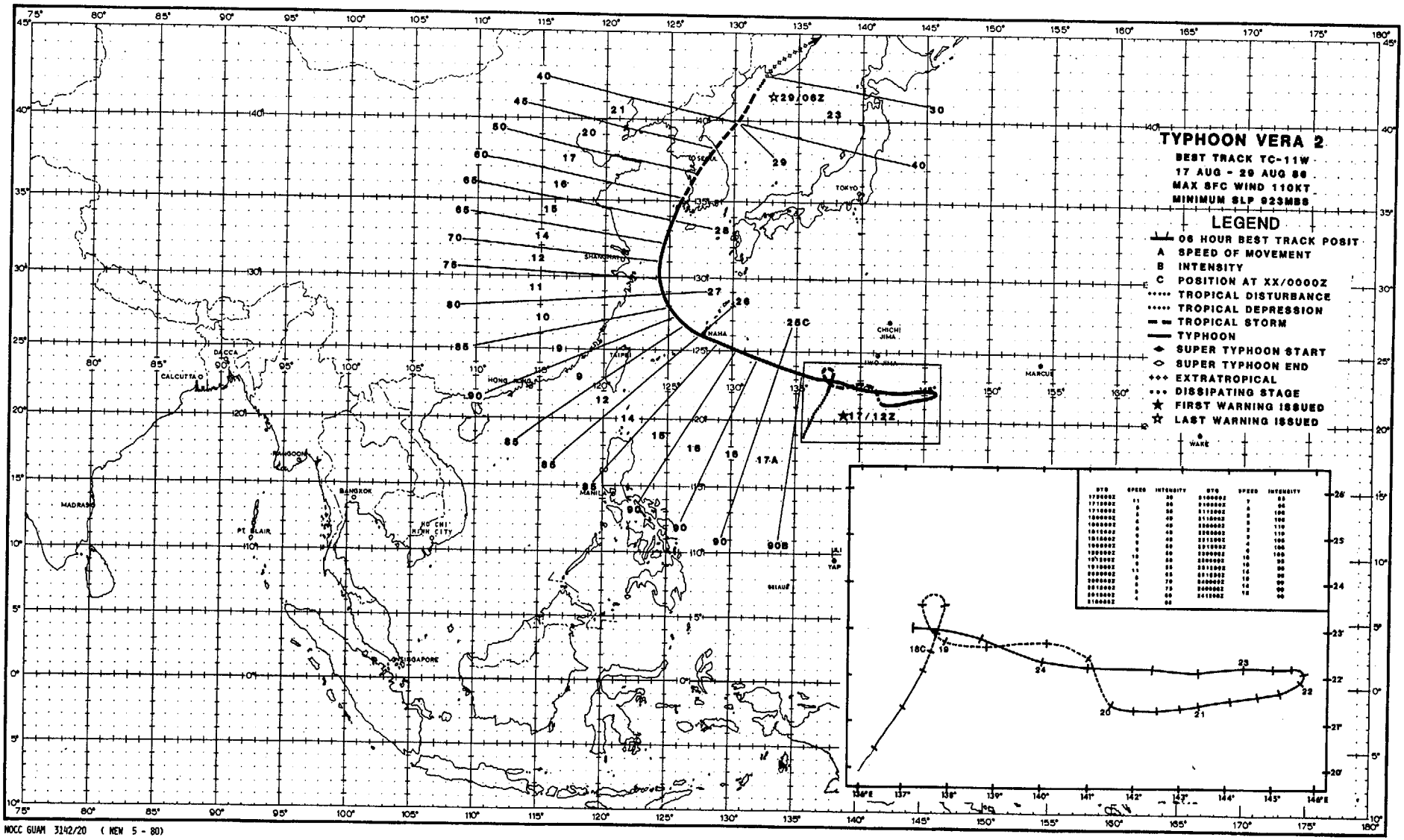


NOCC GUAM 3142/20 (NEW 5 - 80)



NOCC GUAM 3142/20 (NEW 5 - 80)

Typhoon Vera was another classic "monsoon depression" (see Tropical Storm Sarah (09W)) which formed in the most intense and extensive monsoon trough in the western North Pacific since 1974. Locating and forecasting the initial phases of Vera (from 14 to 18 August 1986) within this extensive trough presented unique problems for JTWC. Vera was relocated several times within the monsoon trough as the low-level flow attempted to stabilize around one circulation center. In post analysis, it was determined that Vera was actually two systems: the first (Vera #1) stabilized only briefly, reached tropical storm intensity then dissipated in the central Philippine Sea; the second (Vera #2) formed at the northeast periphery of the monsoon trough, over 360 nm (667 km) from Vera #1, developed slowly and reached typhoon intensity before crossing Okinawa and the Korean peninsula. The problems in locating and forecasting Vera's low-level circulation center were exacerbated by limited aircraft availability (due to other high priority missions for WC-130 aircraft and multiple tasking problems with Typhoons Tip (10W) and Georgette (11E)), sparse synoptic data and inconclusive satellite imagery.

Vera #1 developed on the heels of two typhoons, Tip (10W) and Georgette (11E). On 12 August, Georgette (11E) was moving west-northwestward and was located to the southeast of Wake Island. The onset of the intense and extensive monsoon trough associated with Georgette's inflow region was first noticed at that time, as southwesterly gradient winds of near 30 kt (15 m/sec) were observed at Yap (WMO 91413), Truk (WMO 91334) and Pohnpei (WMO 91348). Georgette (11E) was positioned at the eastern end of this trough (Figure 3-11-1), which extended from the Philippine Islands to the dateline. The onset of the

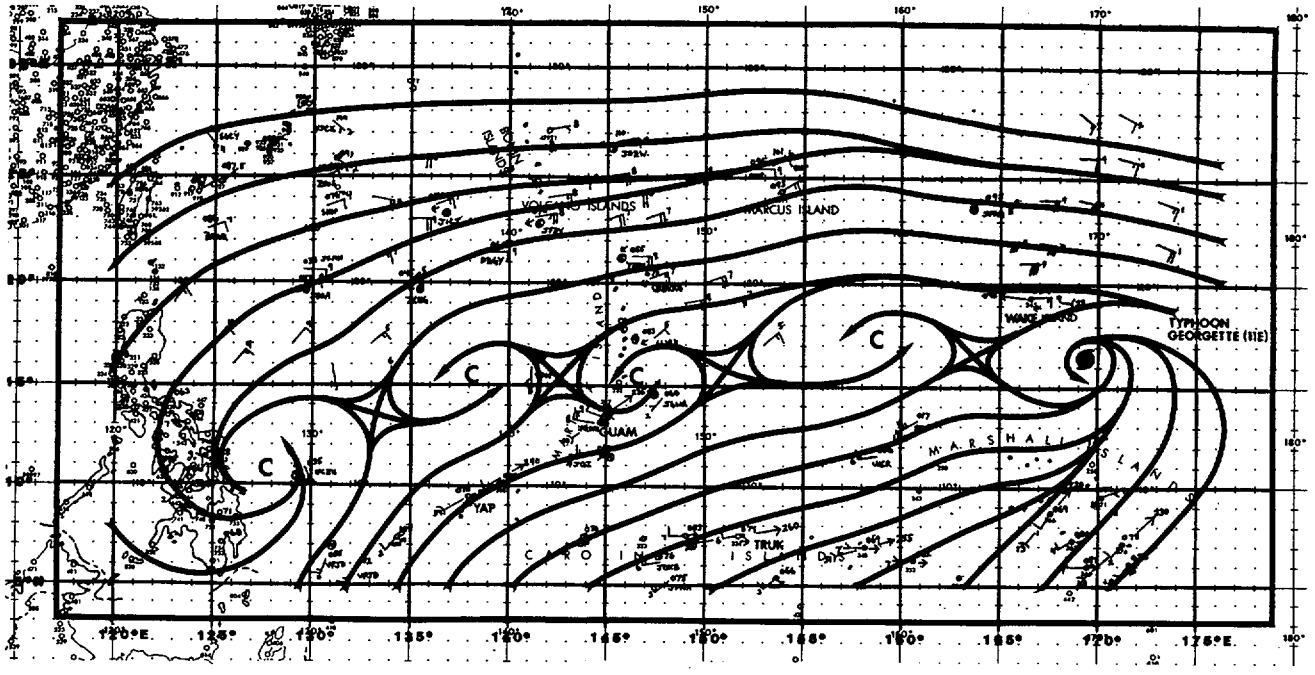


Figure 3-11-1. The surface/gradient analysis at 120000Z August showed the onset of the intense monsoon trough extending from the Philippine Islands to the dateline. Note the strong gradient wind reports at Yap (WMO 91413), Truk (WMO 91334), and Pohnpei (WMO 91348).

monsoon trough was accompanied by an extensive cloud maximum in the Philippine Sea (Figure 3-11-2) where Vera #1 formed. An interesting feature of the trough was the unusually low pressures, which were evident along the axis of the trough between 12 and 15 August. These pressures ranged from 996 to 1006 mb.

By the end of the second week of August gale force westerly winds were present in the southern Philippine Sea and transitory light and variable circulation centers formed along the trough axis. Satellite imagery provided little help in locating any of these circulation centers in the wind field due to the transitory nature of the central convection. Consequently, the circulation that eventually became Vera #1 was never mentioned on the Significant Tropical Weather Advisory (ABPW PGTW) as a suspect area, although several other areas in the monsoon trough were being reported on.

The first Tropical Cyclone Formation Alert (TCFA) was issued on 14 August at 0000Z. This was based on convection that had persisted for 12-hours and was colocated with an analyzed circulation center in the surface/gradient wind field. The TCFA was reissued at 150000Z, as satellite imagery indicated a slight increase in convective curvature. It appeared that the low-level flow was beginning to stabilize around an area located approximately 420 nm (778 km) south-southeast of Okinawa, Japan.

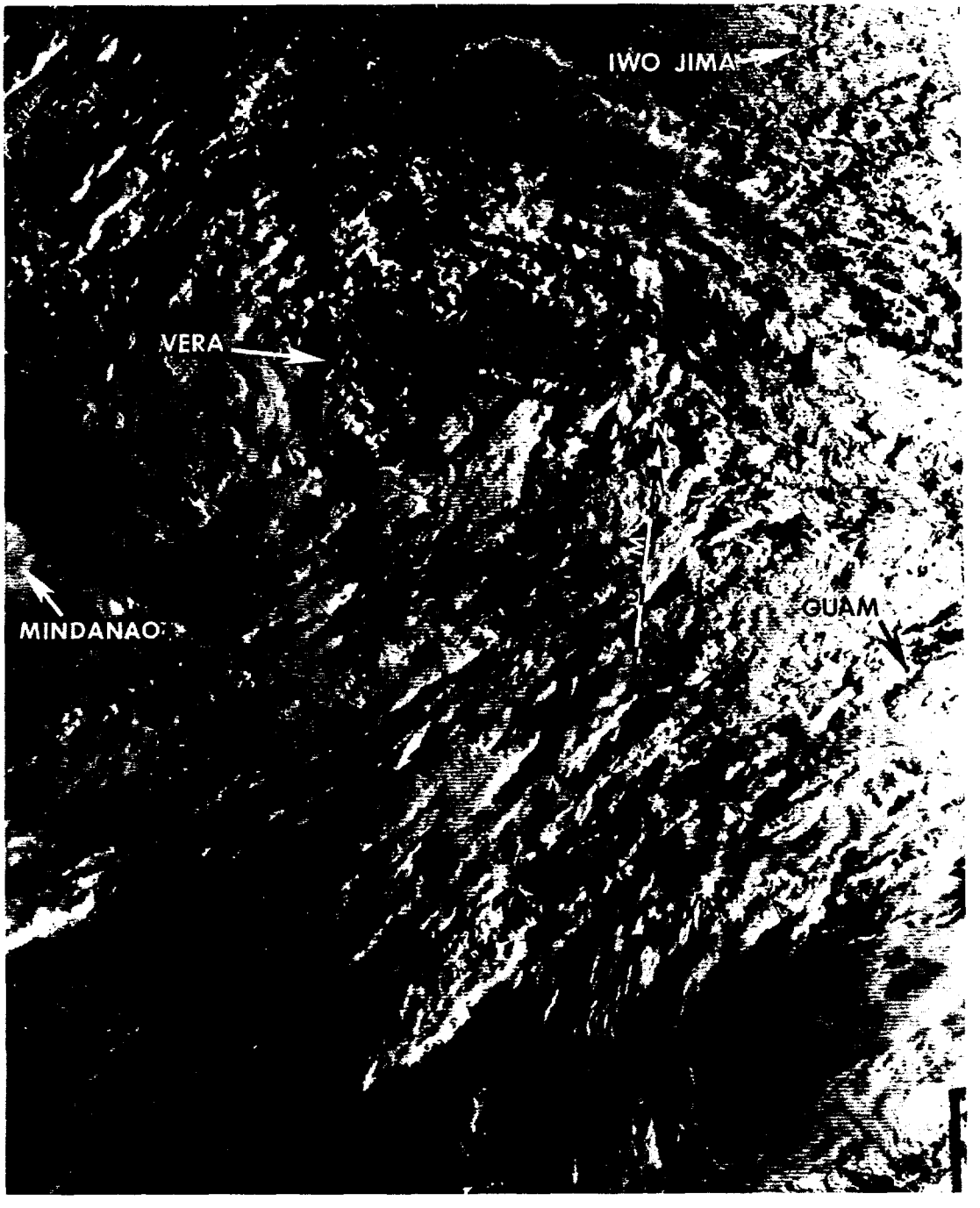


Figure 3-11-2. The area of intense convection that prompted the first TCFA on Vera #1. Note the extensive area of convection in the southwest monsoonal flow in the southern Philippine Sea (132119Z August DMSP visual imagery).

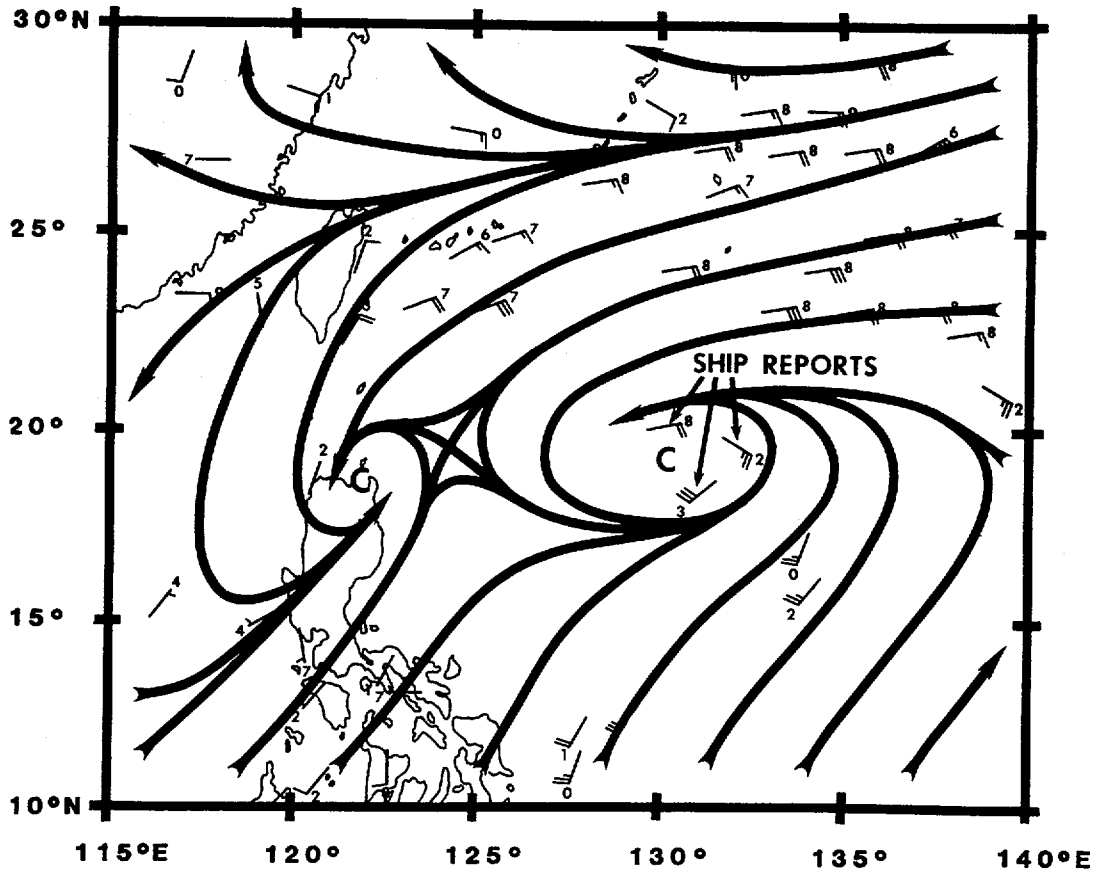


Figure 3-11-3. The 151200Z August ship reports which prompted first warning on Vera #1 at 151800Z August.

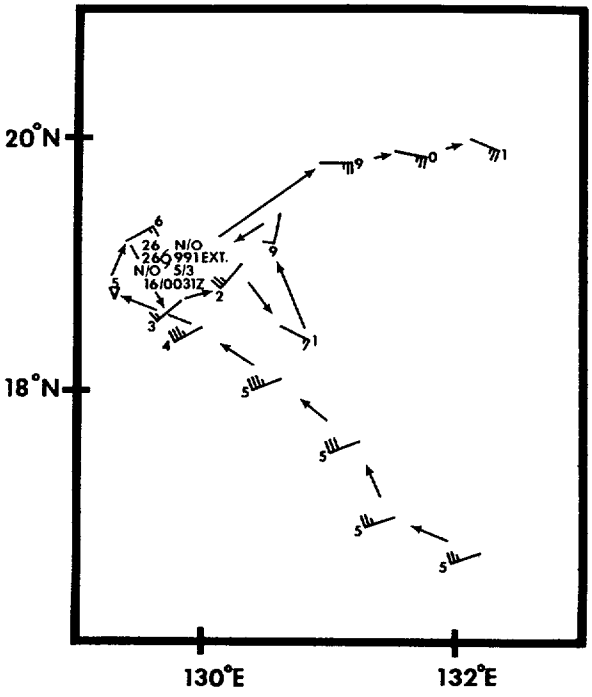


Figure 3-11-4. The August 16th daylight aircraft reconnaissance investigative mission into Vera #1 fixed the low-level circulation center.

At 151200Z, the first warning was issued on Vera #1 (the first system). This warning was prompted by three ship reports (Figure 3-11-3) that defined three quadrants of the 30 kt (15 m/sec) tropical depression. Twelve hours later, the aircraft investigative flight into Vera #1 found winds of 35 kt (18 m/sec) and a minimum sea-level pressure (MSLP) of 991 mb (Figure 3-11-4), confirming the ship report and justifying an upgrade to tropical storm intensity.

The forecast reasoning from 15 August to 17 August, prior to the formation of Vera #2 (the second system) to the northeast, was for Vera #1 to move slowly toward the west-northwest. This was based on the anticipation of the strengthening of the subtropical ridge to the north. However, Vera #1 remained confined to the lower troposphere and embedded in the monsoon trough. Aircraft reconnaissance at 850 mb (5000 ft (1524 m)) was unable to locate the circulation center during a nighttime fix mission on 16 August. At 162333Z, a daylight 1500 ft (457 m) fix mission indicated Vera #1 had moved about 60 nm (111 km) south-southeast of the the last fix mission. At that point Vera #1 was elongated east-west and relatively ill-defined. The surface/gradient analysis at 170000Z (Figure 3-11-5) indicated that the monsoon trough had elongated considerably with a large area of extremely low pressures (about 993 mb). At 171200Z the surface analysis indicated that Vera #1 was no longer evident.

Satellite imagery at 171240Z (Figure 3-11-6) indicated an apparent circulation center (Vera #2) southwest of Tip (10W), which was moving slowly northward and had become the dominant system in the

monsoon trough. The analysis (Figure 3-11-5) was 12-hours prior to the formation of Vera #2 that was (perhaps mistakenly) maintained as Vera after being relocated more than 360 nm (667 km) to the east-northeast. The satellite data prompted the first warning on Vera #2 at 171200Z. The dramatic relocation was verified at 180716Z, when the first aircraft reconnaissance fix position in over 30-hours (Figure 3-11-7) confirmed the presence of the 50 kt (26 m/sec) system embedded in the monsoon trough.

The sudden and dramatic formation of Vera #2 caused many problems for the fleet customers as well as for the forecasters. In essence, Vera #1 had been forecast to move slowly toward the west-northwest for three days when the relocation occurred, placing the system 360 nm (667 km) to the east-northeast in a six hour period. Confusing and conflicting satellite imagery provided little insight into the location of the system during these stages. At 171200Z, Vera #2 was at tropical depression intensity and moving slowly northward. For the next three days, Vera #2 intensified slowly, moving erratically at first, and then slowly eastward within the monsoon trough. The intense trough was again asserting its influence on the system's track, as the remnants of Tip (10W) provided the "anchor" at the eastern end of the monsoonal flow. Vera #2 continued to move eastward with the monsoon west-southwesterlies until the 22nd, when it slowed and began to track northward.

The synoptic situation governing Vera #2's movement began to change on the 21st, when a small surface ridge appeared to be building to the north of Vera #2. This ridge continued to build, helped perhaps by increasing upper-level convergence to the east-northeast of Vera #2, enhancing subsidence in the upper troposphere and ridging at the surface.

Between 220000Z and 221200Z, Vera #2 turned northward, and then westward, as the low- to mid-level ridge became firmly established to the north. The shift in the steering flow is evident in the change in the 700 mb Numerical Variational Analysis (NVA) streamline analysis between 220000Z and 221200Z (Figures 3-11-8 and 3-11-9). Apparently, the mid-level trough associated with the remnants of Tip (10W) had completely disappeared by 221200Z and was replaced by ridging northeast of Vera #2. This ridge provided the steering flow until Vera #2's recurvature on 27 August. Vera #2 reached its maximum intensity of 110 kt (57 m/sec) and MSLP of 923 mb on 21 August, just prior to turning westward toward Okinawa.

Vera #2 continued to move west-northwestward from the 22nd through the 26th, passing directly over the island of Okinawa late on the 25th (Figure 3-11-10). The forecast had provided those on Okinawa with 66-hours of warning before the closest point of approach (CPA) occurred. All aircraft and ships had been evacuated, sortied, or secured long before Vera #2 hit with maximum sustained winds (over water) of 85 kt (44 m/sec).

The recurvature and extratropical transition phase of Vera #2's track began on 26 August. Upon reaching the western periphery of the subtropical ridge, Vera #2's movement had slowed to 9 kt (17 km/hr) and turned northwestward at approximately 260600Z. Vera #2 turned northward at about 270000Z and passed 160 nm (296 km) east of Shanghai 12-hours later. After passing east of Shanghai, Vera #2 began to accelerate north-northeastward. By the 28th, the tropical cyclone had lost its connection with the low-level monsoonal westerlies and weakened to 60 kt (31 m/sec). Figure 3-11-11 shows Vera #2 just prior to landfall near Kunsan AB, Republic of Korea, with a large cirrus shield to the north of the exposed low-level circulation, indicative of a tropical cyclone transitioning into an extratropical system. Vera #2 cleared the Korean peninsula at 281800Z with an intensity of only 45 kt (23 m/sec) and continued accelerating northeastward. It completed extratropical transition at 290600Z in the Sea of Japan.

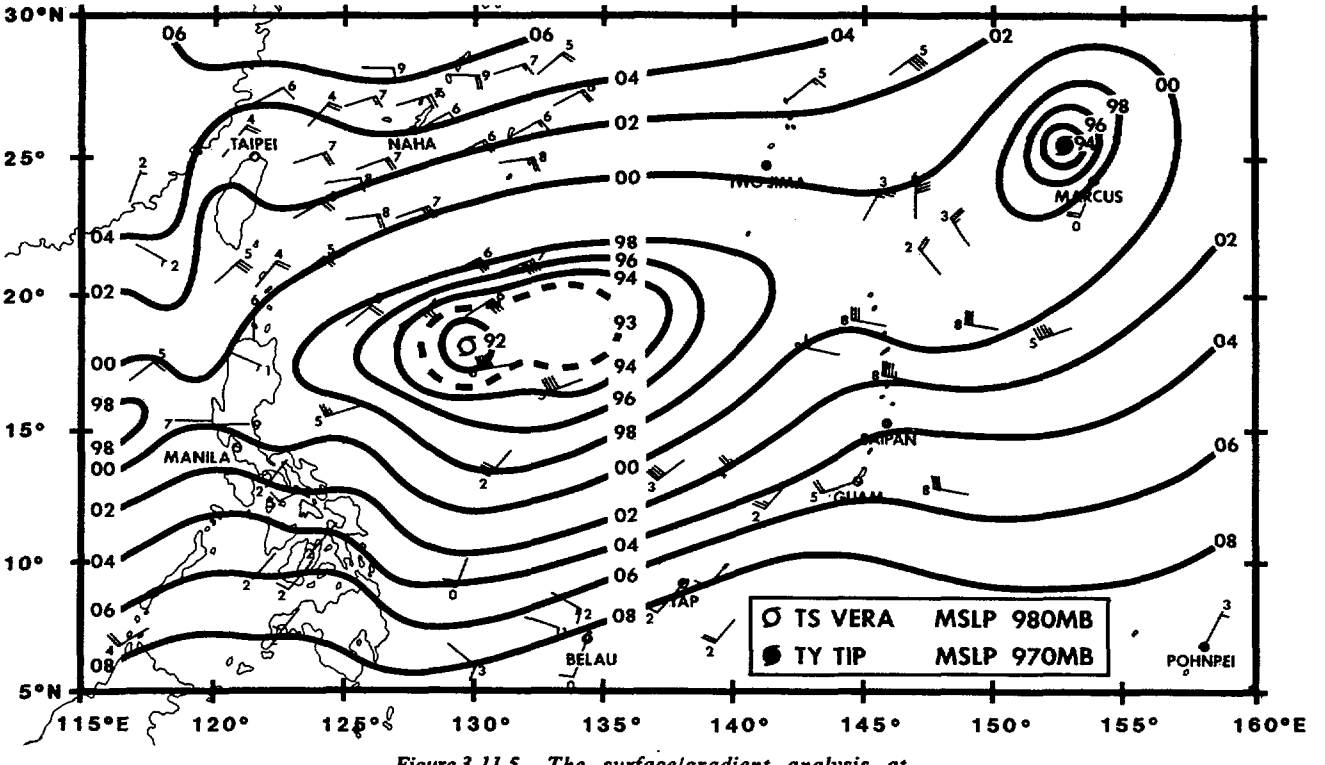


Figure 3-11-5. The surface/gradient analysis at 170000Z (12-hours prior to the formation of Vera #2). Note the elongated trough to the east and west of Vera #1.

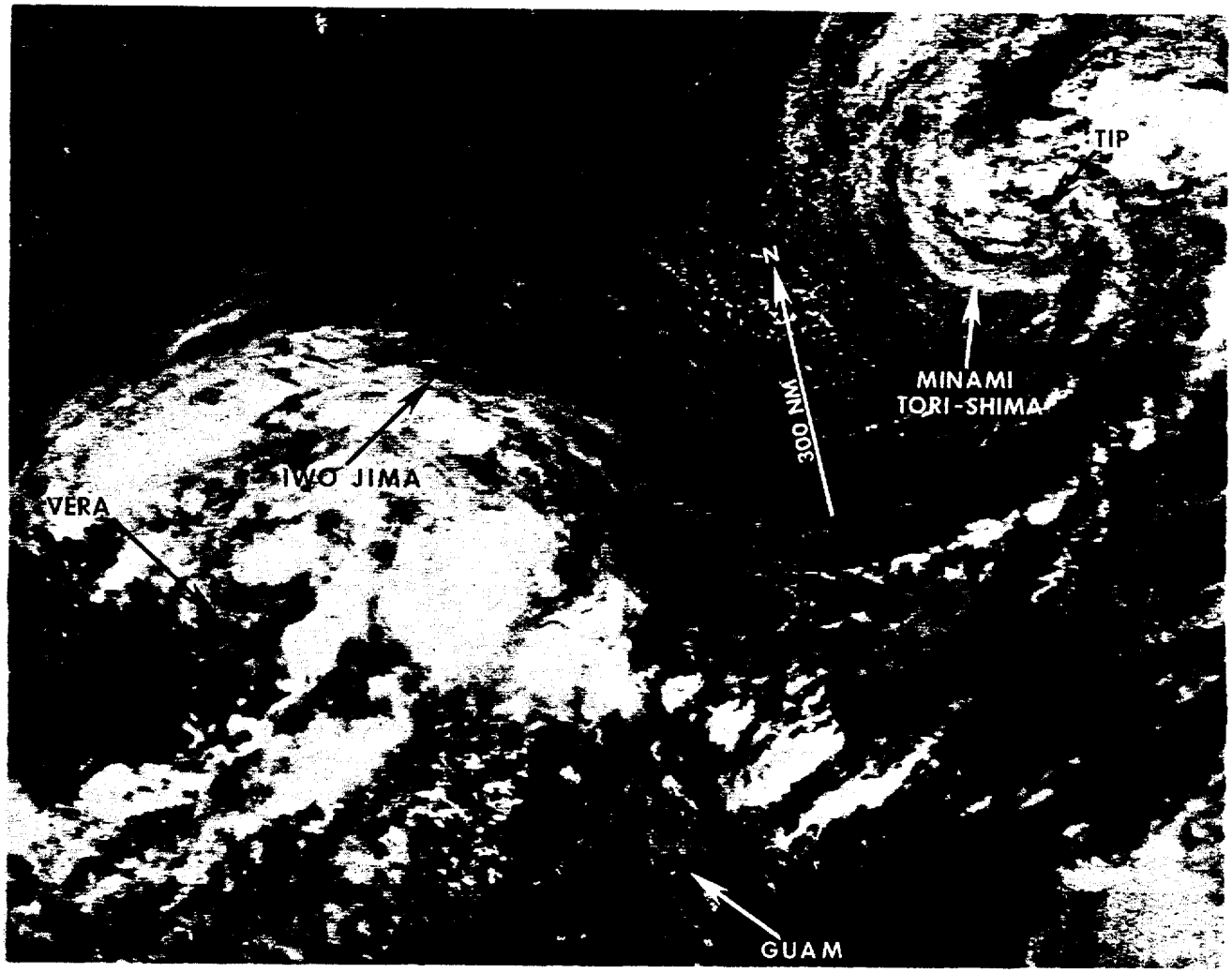


Figure 3-11-6. Typhoon Tip and the early stages of Vera #2 (171240Z August DMSP visual imagery).

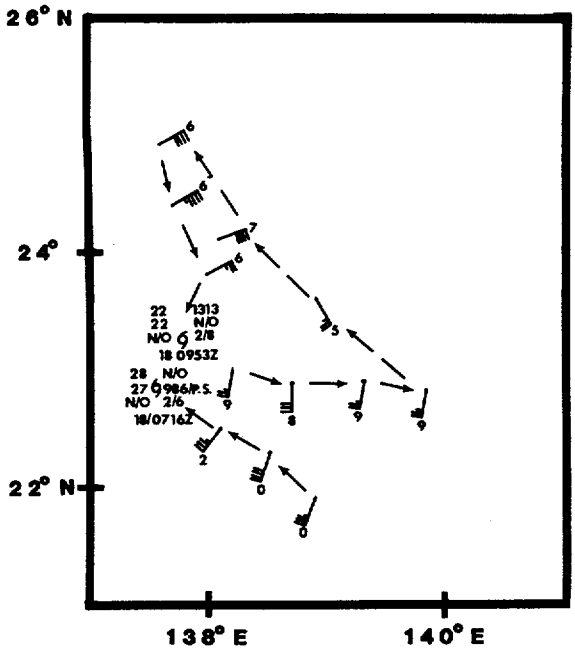


Figure 3-11-7. First aircraft reconnaissance fix mission after relocation to Vera #2 (180716Z).

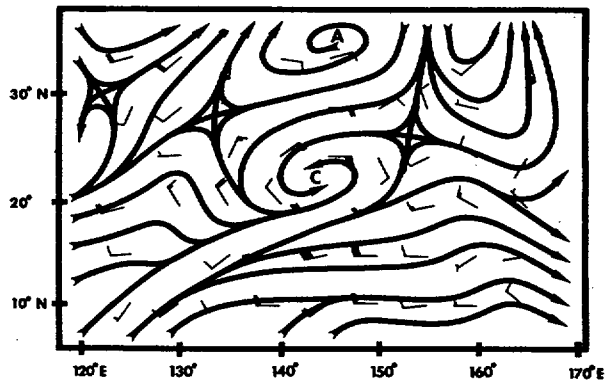


Figure 3-11-8. The 220000Z August 700 mb NVA analysis showing the trough (associated with the remnants of Typhoon Tip (10W)) to the northeast of Vera #2.

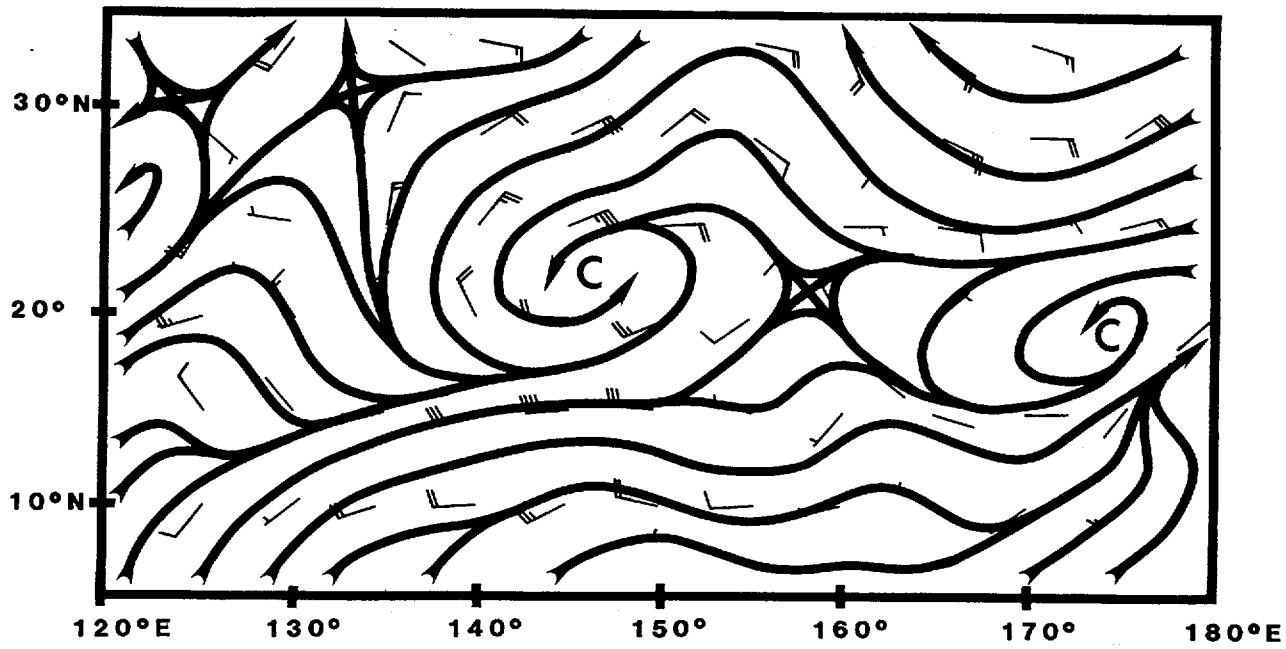


Figure 3-11-9. The 221200Z August 700 mb NVA analysis showing a ridge (in place of the trough 12-hours earlier) north and northeast of Vera #2.

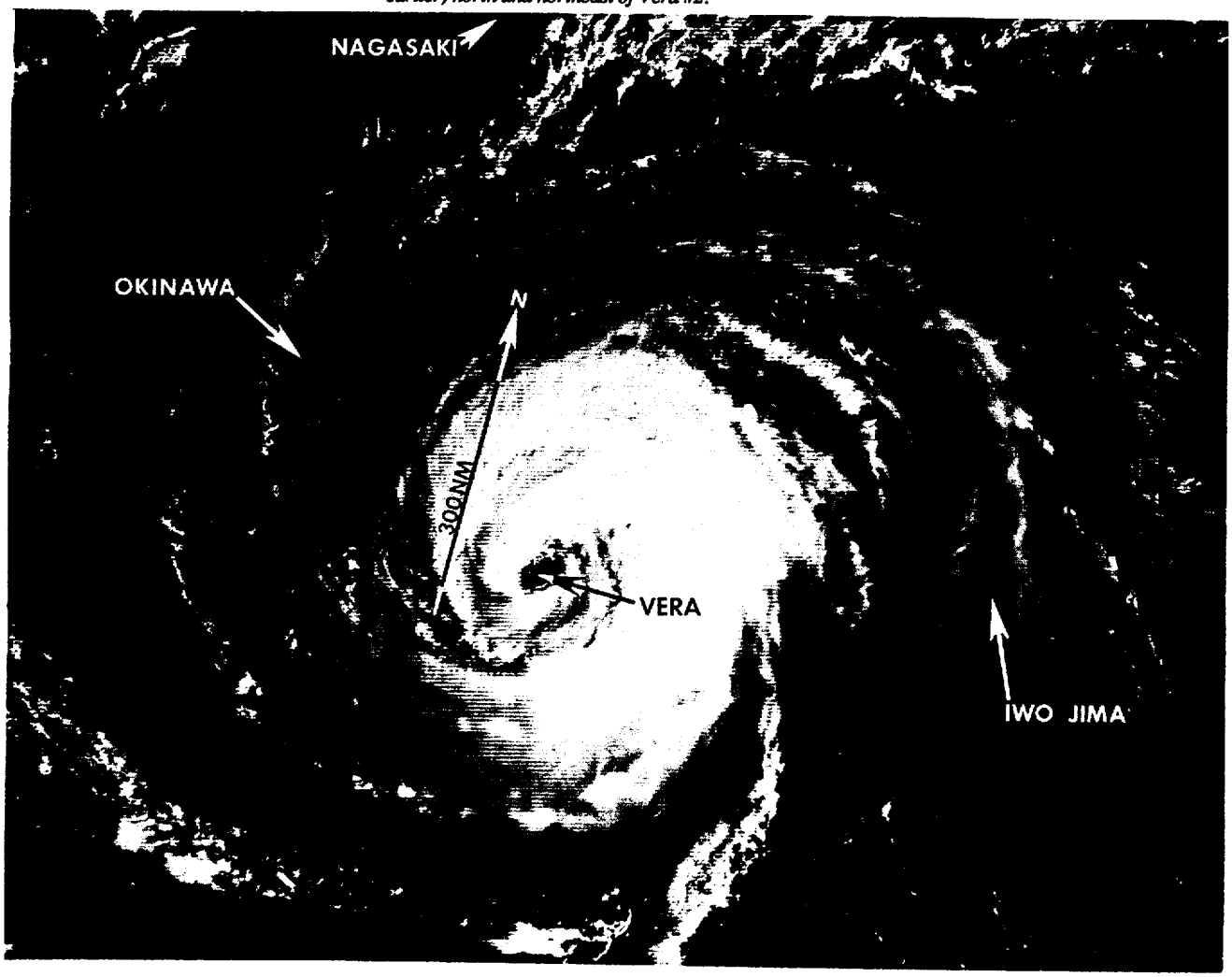


Figure 3-11-10. Vera #2 at typhoon intensity as it approached Okinawa (250039Z August DMSP visual imagery).

In addition to the problems of finding and forecasting the initial low-level center, Vera #2 caused considerable damage and loss of life. It severely impacted civilian shipping and military operations at sea. Okinawa, in contrast, because of the early warning provided, experienced only slight damage; mostly to power lines for private homes. One fisherman was killed. Kadena AB recorded peak wind gusts of 84 kt (43 m/sec). High seas, however, placed several ships at sea in distress. In Shanghai, seven people were killed and 28 injured when Vera #2 passed 160 nm (296 km) east of the city. The New China News Agency (NCNA) reported more than 500 homes were destroyed and 3,000 emergency workers were recalled to restore electrical supplies and to ensure dikes along the Huangpu river and the coast were secure. NCNA also reported that more than 3,000 vessels sought shelter as Vera #2 approached. On the Island of Cheju, 28 houses were destroyed, leaving 50 people homeless. In South Korea, six people were killed and over one million dollars worth of damage was reported. The most extensive damage to U.S. military facilities was reported at Taegu AB, where more than 75 trees were felled and power lines were downed. The roofs of several buildings were blown away.

In retrospect, Vera underscores the difficulty of positioning and forecasting tropical cyclones that form in strong monsoonal troughs. In addition, the eastward movement of Vera #2 for three days was an interesting anomaly that was perhaps influenced by the intense monsoon trough that extended throughout the entire western North Pacific for most of August.

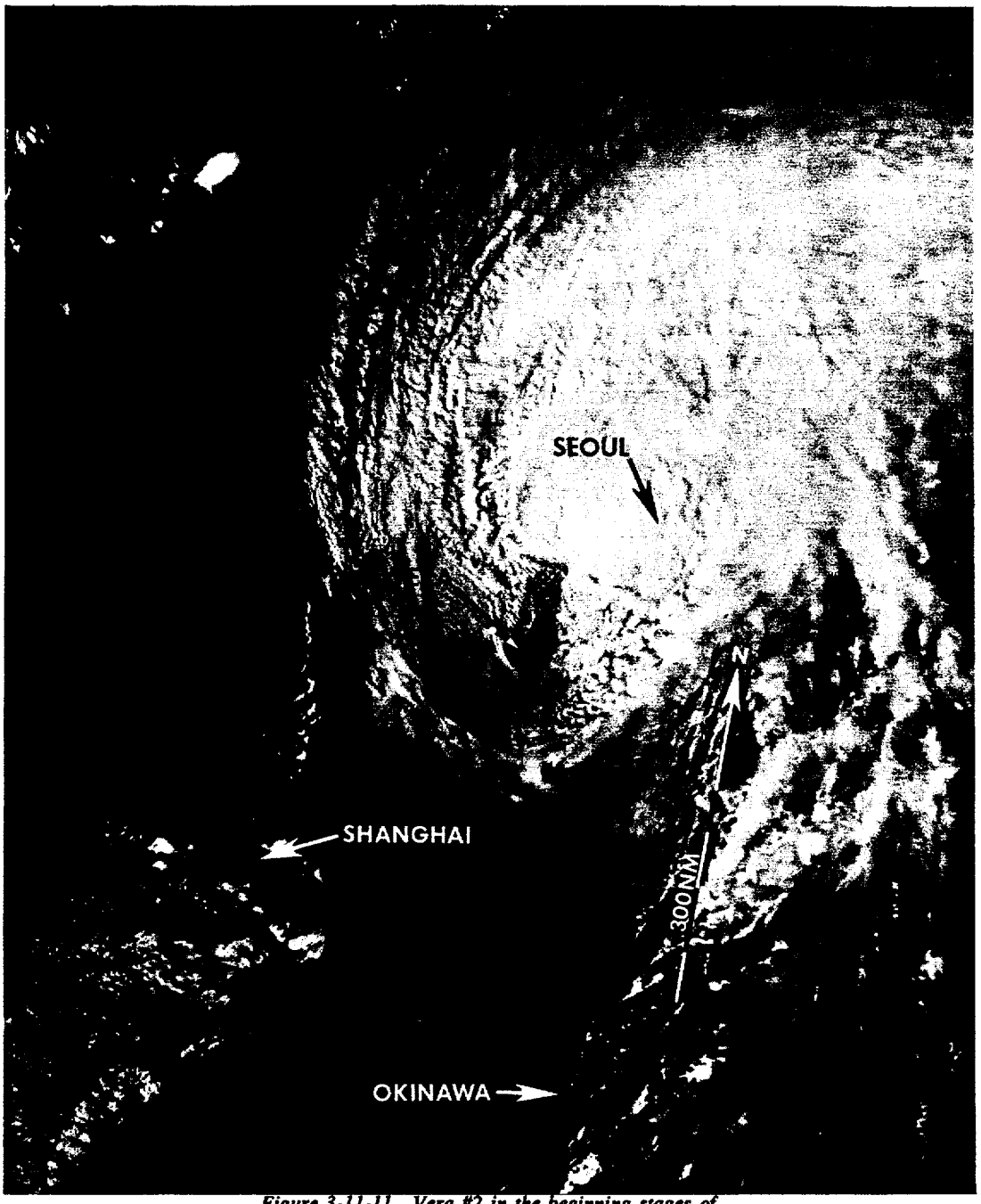


Figure 3-11-11. Vera #2 in the beginning stages of extratropical transition just prior to landfall near Kunsan AB, Republic of Korea (280621Z August NOAA visual imagery).